Quick Guide to Measurements
-Filmetrics F54-UV-

- Start-up proceddure
  1. Log into FOM and enable the hardware.
  2. On the desktop menu, open the "FilMapper" software and wait for the motor initialization to complete.
  3. Return to the desktop and open the "UVSource."
  4. Enable "Deuterium Lamp On," "Tungsten-Halogen Lamp On," and "Shutter Open."
  5. Wait for 5 to 10 minutes for the lamp light to stabilize.
     a. Wait for 5 minutes for a quick measurement.
     b. Wait for 10 minutes for an accurate measurement.

- Taking a Baseline
  1. From the "Measure" tab, use the "Go To..." command to move the stage to the load position (X = 0, Y = 100), and load the sample onto the stage. Activate "Live Video" if it is not already activated.
  2. On the right panel, press the "Baseline…" button, followed by the "Take Sample Reflectance" button.
  3. Navigate the sample to the location of interest and hit "Auto Focus."
  4. Press "OK" to perform reflectance measurements.
  5. Choose the reflectance standard material from the drop-down menu and press the "Take Reflectance Standard" button.
  6. Move the stage back to the load position (X = 0, Y = 100), unload your sample, and load the reflectance standard.
  7. Bring the stage back to the measurement position (X = 0, Y = 0) and hit "Auto Focus."
  8. Press "OK" to perform baseline measurements. Wait for the stage initialization to complete.

- Measurement
  1. Unload the reflectance standard and load your sample back onto the stage.
  2. Navigate your sample using arrows in the "Live Video" tab or using the "Go To…" command.
  3. Select the appropriate recipe from the drop-down menu on the right panel.
  4. Press "Edit Recip…" to adjust the initial values of the fitting parameters, such as thicknesses.
  5. Press the "Measure" button on the right panel to start the reflectance measurement.
     a. The measured spectra and fitting results will be displayed in the middle.
     b. The fitted thicknesses and goodness of fit (GoF) are shown in the lower right corner.
     c. Save the measurement result from the "File" menu.
     d. You can access previous results from the "History" tab.

- Shutting down
  1. Move the stage to load position (0, 100) and unload your sample.

2. Close “FLMapper” software. In the “UVSource” software, uncheck “Deuterium Lamp On”, “Tungsten-Halogen Lamp On”, and “Shutter Open”
3. Log out from FOM.

Filmetrics F54-UV

1. Purpose

Standard operating procedure for the Filmetrics F54. The Filmetrics F54-UV is a non-contact reflectometer. It uses a large library and pre-set recipes to measure transparent and semi-transparent film thicknesses. This model has a UV light source and a full spectral range of 200 nm to 1100 nm.

2. Scope

This SOP is intended for general purpose use of the Filmetrics F54.

3. Prerequisites

Users must have cleanroom access.

4. Responsibilities

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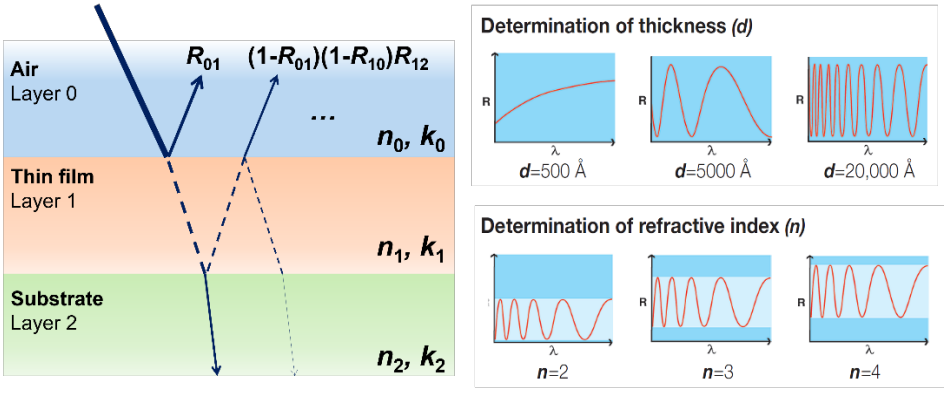
5. Tool description

Filmetrics F54 is a tool used for characterizing the thickness and optical properties of thin films based on spectral reflectance (SR). The main differences between SR and ellipsometry are as follows: ellipsometry measures reflectance at a low angle of incidence and also measures two different polarizations (parallel and perpendicular to the plane of incidence). On the other hand, SR measurements utilize light that is reflected at a normal angle to the surface, allowing the polarization effect to be ignored. SR with normal incidence offers advantages such as low cost and high efficiency, along with fast scanning speed, but it lacks sensitivity for films thinner than a few nanometers. For characterizing thinner films, the staff recommends using the Woollam Ellipsometer.

Spectral reflectance basics: Suppose we have polarized light traveling inside a material with a refractive index of *n* and an extinction coefficient of *k*. This light can be described in its simplest form at a fixed time as $A\cos\left(\frac{2\pi nx}{\lambda}\right)exp\,(-\frac{2\pi nx}{\lambda})$, where *x* is the distance, and λ is the wavelength of the light. The discontinuity in *n* and *k* determines the fraction of the light that is reflected. For the light reflected off of material into the air at a normal angle to the surface, the fraction of reflected light (*R*) can be determined as $R = \frac{(n-1)^2+k^2}{(n+1)^2+k^2}$.

In the case of thin films, the light reflected from the top and bottom interfaces can either constructively or destructively interfere with each other, due to the difference in optical path length. Constructive interference occurs when $2nd = i\,\lambda$, and destructive interference occurs when $2nd = \left(i+\frac{1}{2}\right)\lambda$, where *d* is the film thickness, and *i* is an integer.

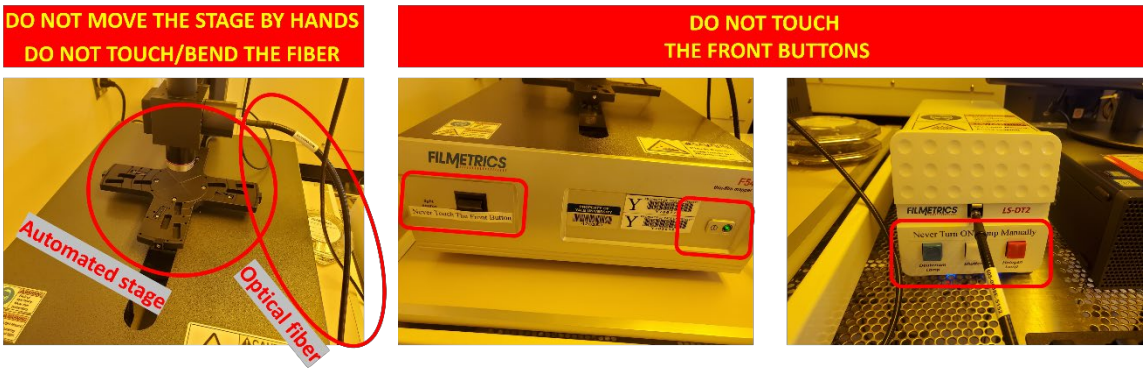
As a result, the reflectance of measured thin films varies periodically with wavelength, with its periodicity and amplitude highly dependent on film thickness and optical constants, as shown in the figure below. By fitting the obtained reflectance spectra, we can estimate the thickness, refractive index, and extinction coefficient of each layer.



6. Procedure

Before You Start:

Warnings

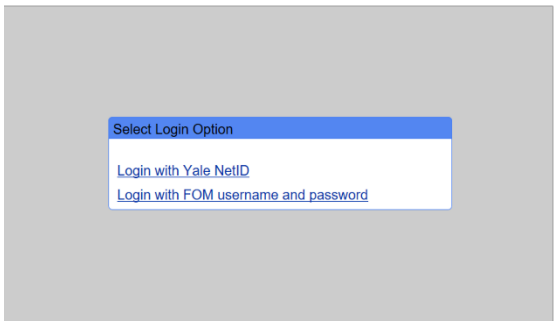


- Refrain from touching the fiber optic cable to avoid damaging the system.
- This system uses an automated stage. Do not move it by hand and be sure all hands and objects are clear when starting the software and scanning. Never leave objects on the system surface.
- Please refrain from manually pressing power buttons or lamp switches. The tool is typically meant to be left on, and the lamps should be controlled through the software.

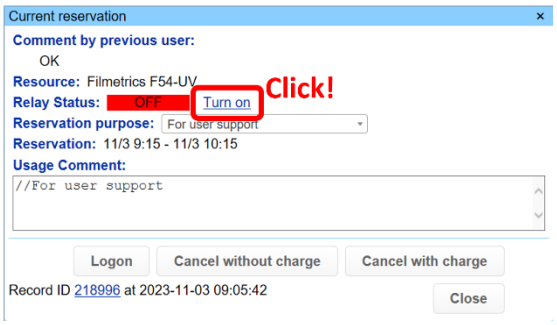
Start Up Procedure:

1. Log into FOM to enable the hardware.

Log into FOM

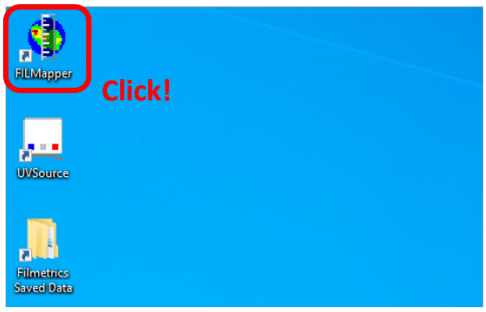


Turn on the device

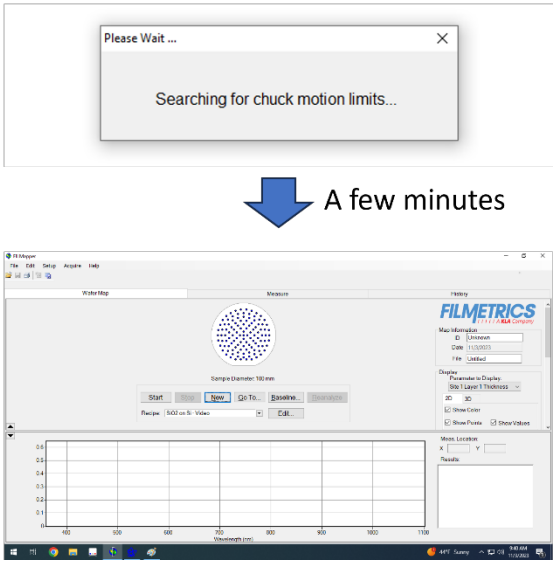


2. Open the **FILMapper** software available on the desktop and wait for the software to initialize.

Open FLMapper

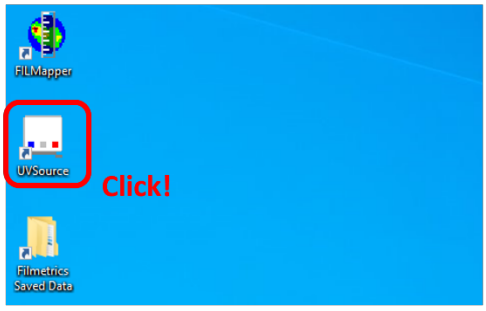


Wait for the motor initialization to be completed.

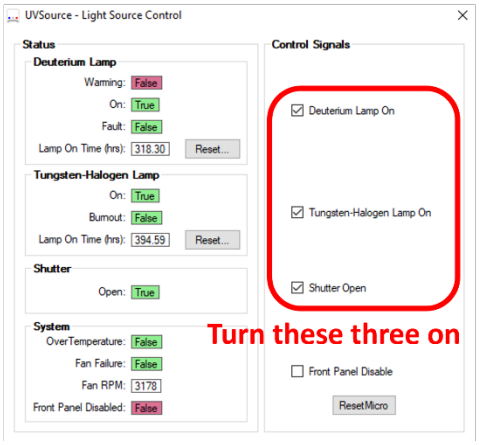


3. Return to the desktop and open the UVSource light source control. Select Tungsten-Halogen Lamp On, Deuterium Lamp On, and Shutter Open.

Open UVSource

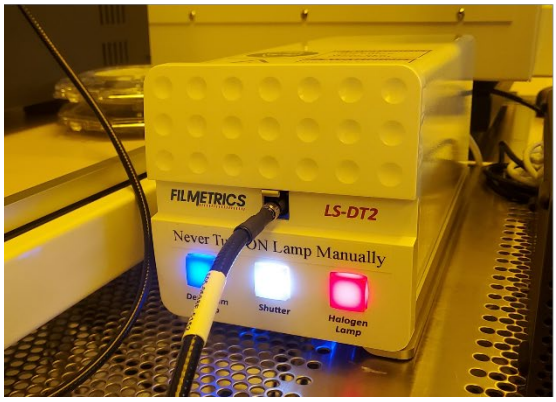


Turn on the lamps and shutter



4. Check if all three lights on the UV source front should be lit. Wait at least five minutes for the lamp sources to stabilize. Wait fifteen minutes for best results.

Check if lamp lights are all lit



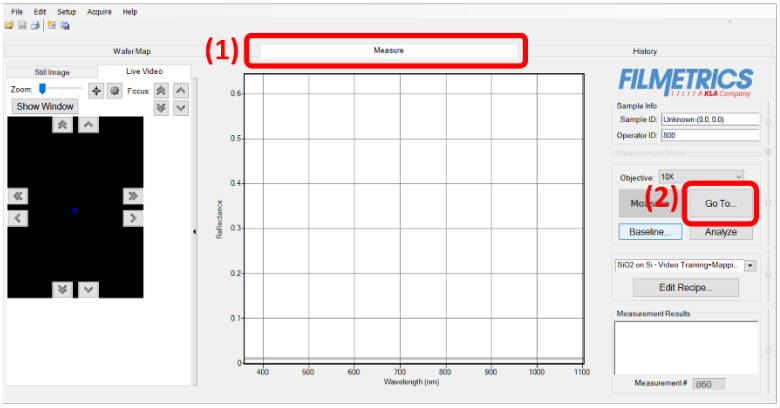
Wait for the lamps to be warmed up

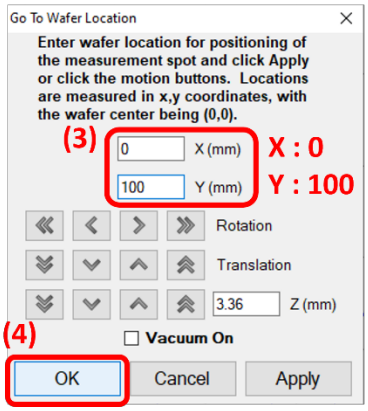
- For basic characterization: Wait for ≥ 5 min.
- For more precise measurements: Wait for additional 10 min. (15 min. total).

Taking a Baseline: The system baseline measures known values to calculate measurement offsets. You will first take a baseline reflectance of your sample and then the Si standard wafer.

1. From the **Measure** tab, use the "**Go To…**" command to bring the system chuck out towards you (X=0, Y=100).

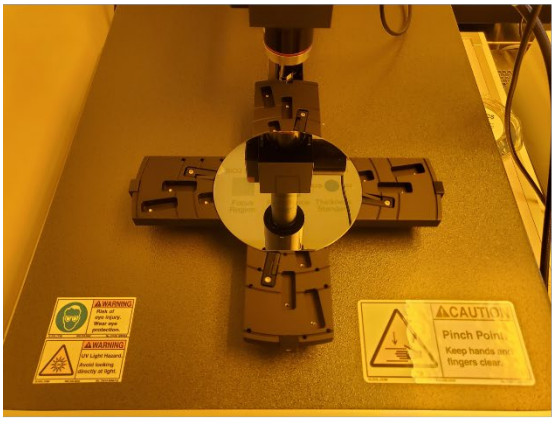
Go to the sample loading position



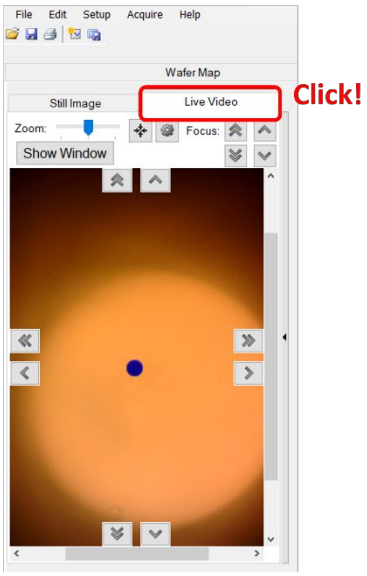


2. Load your sample on the center, and then activate the "Live video" on the left side of the Measure tab.

Load the sample on the center

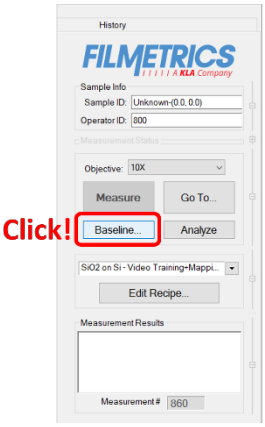


Activate Live Video

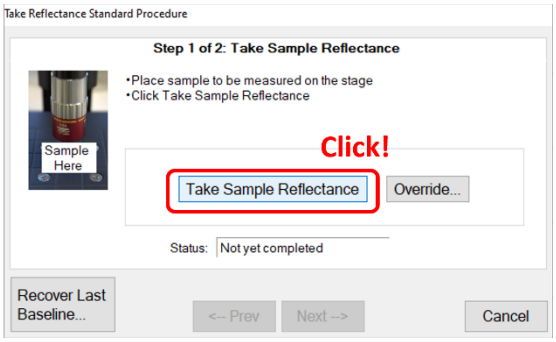


3. Press the "**Baseline…**" button followed by the "**Take Sample Reflectance**" button.

Hit "Baseline …"



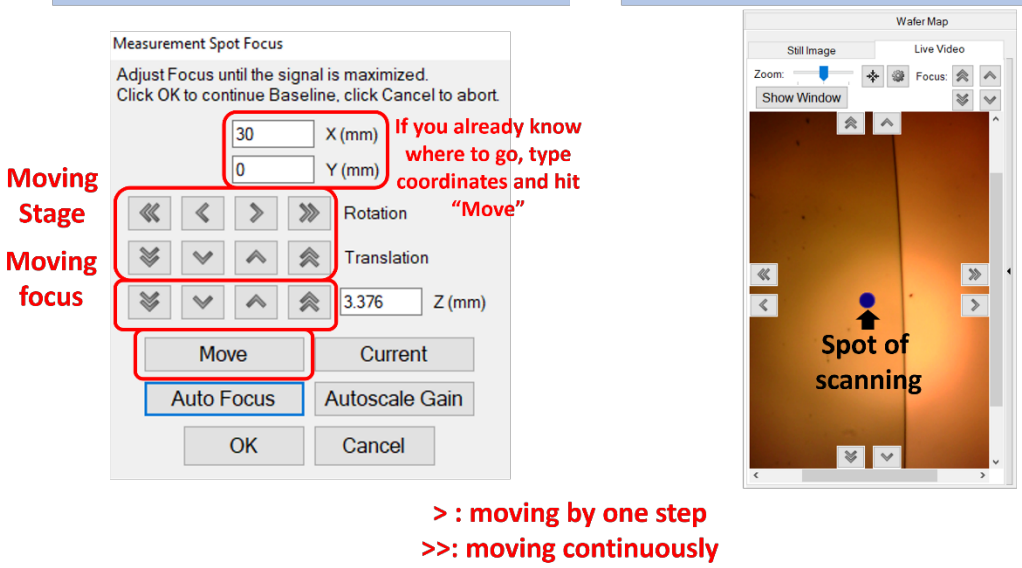
Hit "Take Sample Reflectance"



4. If your sample is inhomogeneous, navigate to the location of interest by using arrows in the "Measurement Spot Focus" dialogue or by typing the coordinates and pressing "Move."

Move the stage to navigate to the sample location for measurement

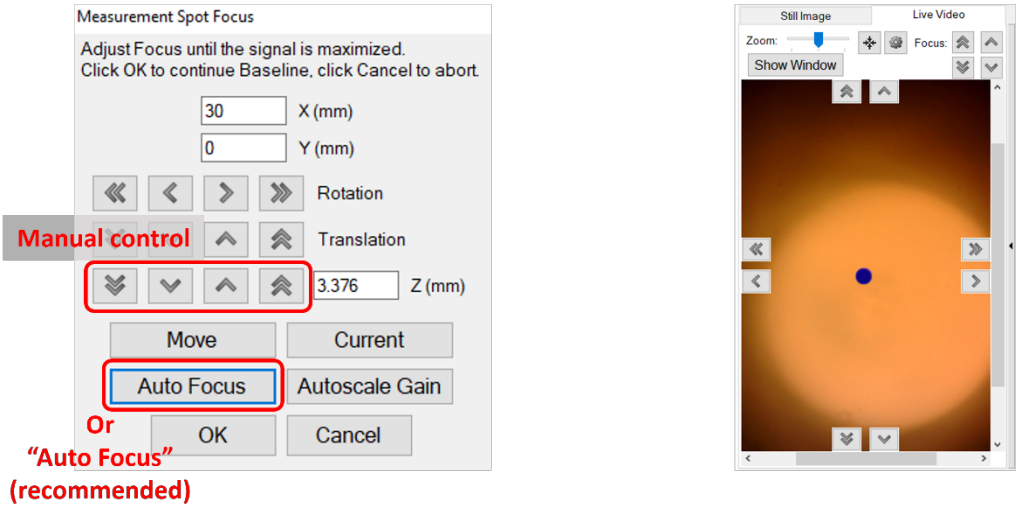
Check the measurement spot on the "Live Video"



5. Adjust the focus on your sample to maximize intensity either by using the "Measurement Spot Focus" dialogue or by using "Auto Focus" (recommended) when appropriate.

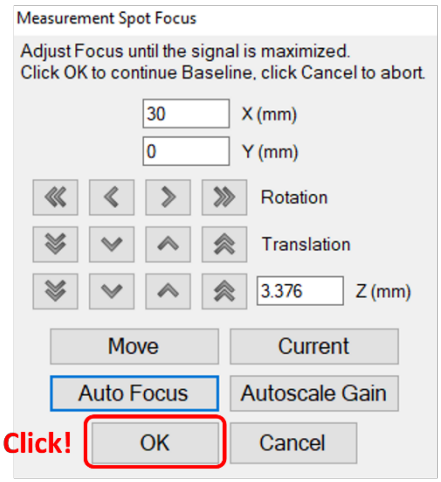
Either use "Auto focus" or manually adjust focus to maximize intensity

Live Video at max intensity

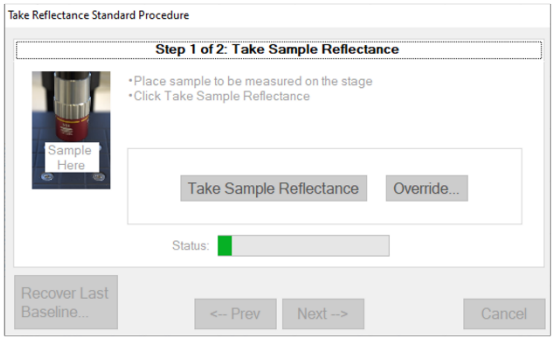


6. Press OK to measure reflectance.

Hit "OK" to start baseline measurement

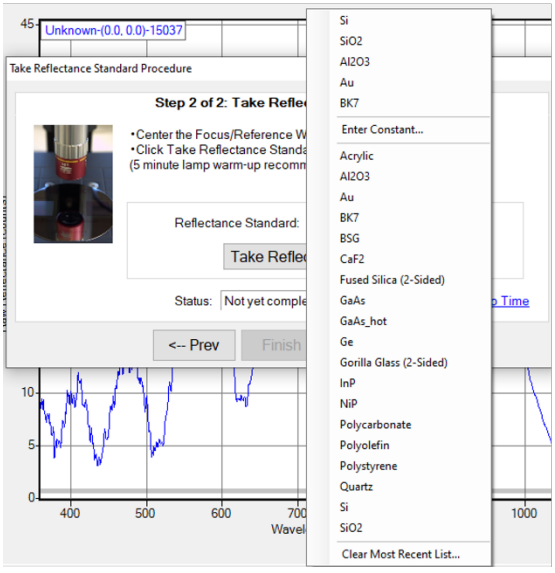


Wait until reflectance measurement to be done

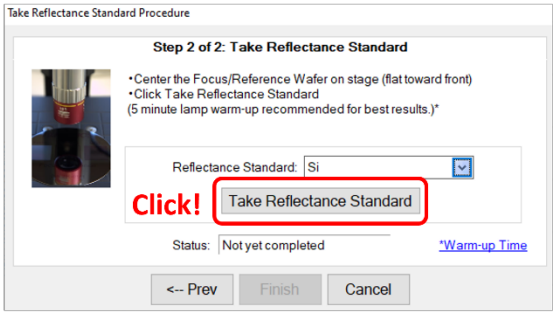


7. Choose your reflectance standard materials from the drop-down menu. Press the "Take Reflectance Standard" button to initiate the reflectance measurement of the standard sample.

Choose reflectance standard

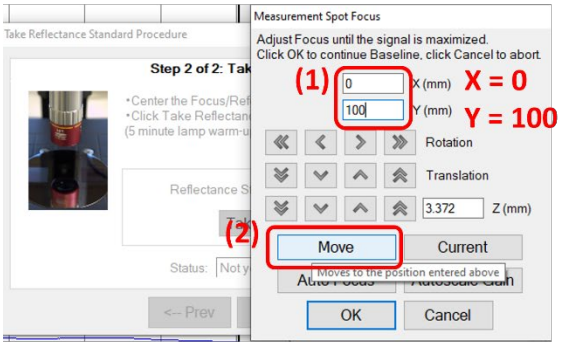


Hit "Take Reflectance Standard"



8. Move the stage to the loading position (X = 0, Y = 100). Unload your sample and load the reflectance standard. If your reflectance standard is silicon (Si), you will require a silicon wafer, either your own or one available on the tool.

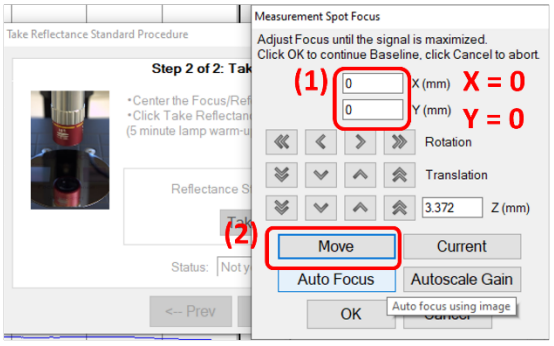
Navigate the stage to sample loading position



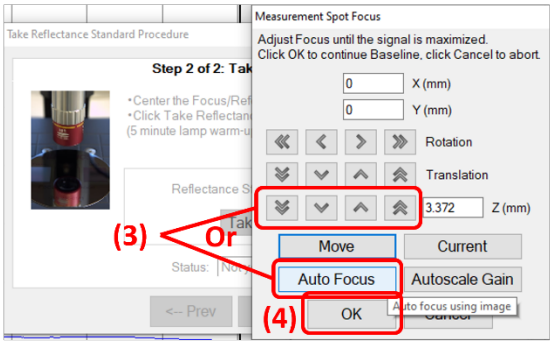
Unload your sample / load reflectance standard

9. Navigate the sample to the measurement position. Focus on the reflectance standard either by using the measurement spot focus dialogue or the “Auto Focus”. Please note that if you used "Auto Focus" for sample reflectance, also use "Auto Focus" for the reflectance standard. Press "OK" to generate baseline values.

Navigate the stage to sample measurement position

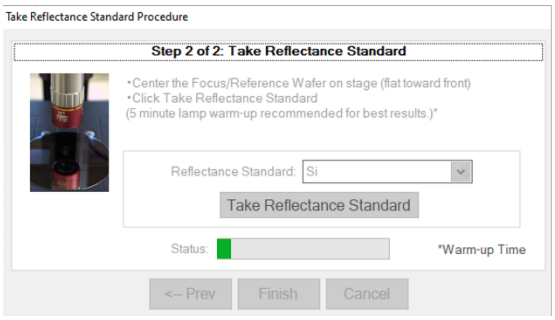


Focus on reflectance standard / hit “OK”

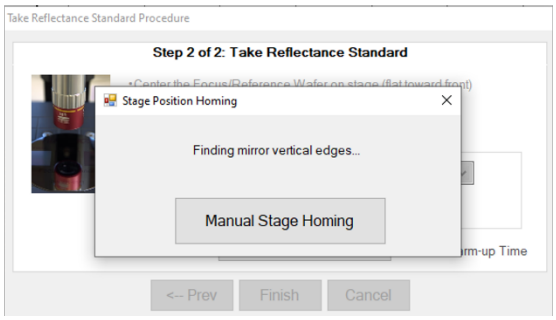


10. Please wait until the baseline measurement is complete. Once the baseline measurement is finished, the stage motion initialization process will begin. Please do not interrupt the initialization process, as it will take less than a minute.

Wait for baseline measurement



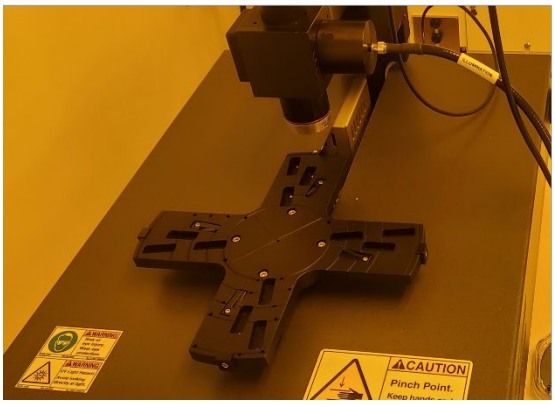
Wait for stage initialization



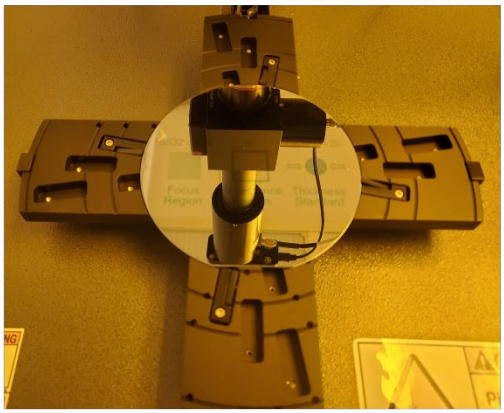
Measurement: Basic single-spot measurements are taken using the **Measure** tab. Contact a staff member for instructions on how to use Wafer Mapping.

1. Unload reflectance standard and load again your sample.

Unload Reflectance Standard

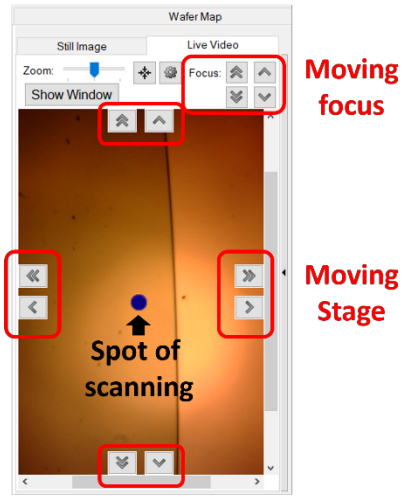


Load your sample back

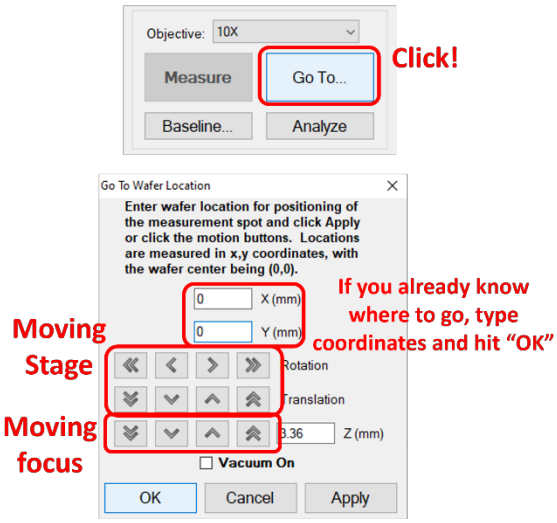


2. Navigate your sample using the on-screen arrows in the “Live Video tab” or using “**Go To…**” dialogue. The dot in the center is the system’s measurement location.

Navigating at Live Video tab



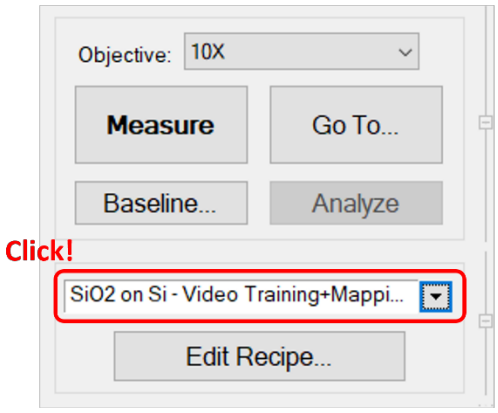
Navigating using "Go To…" command



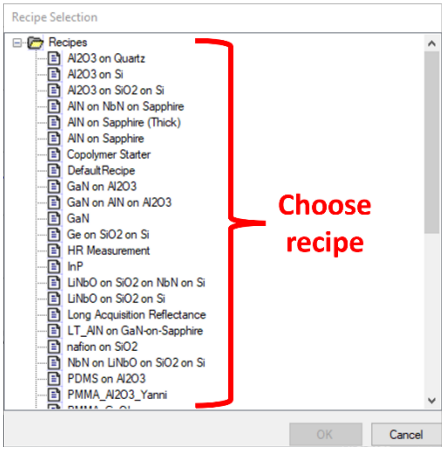
> : moving by one step
>>: moving continuously

3. Select the measurement recipe in the drop-down menu.

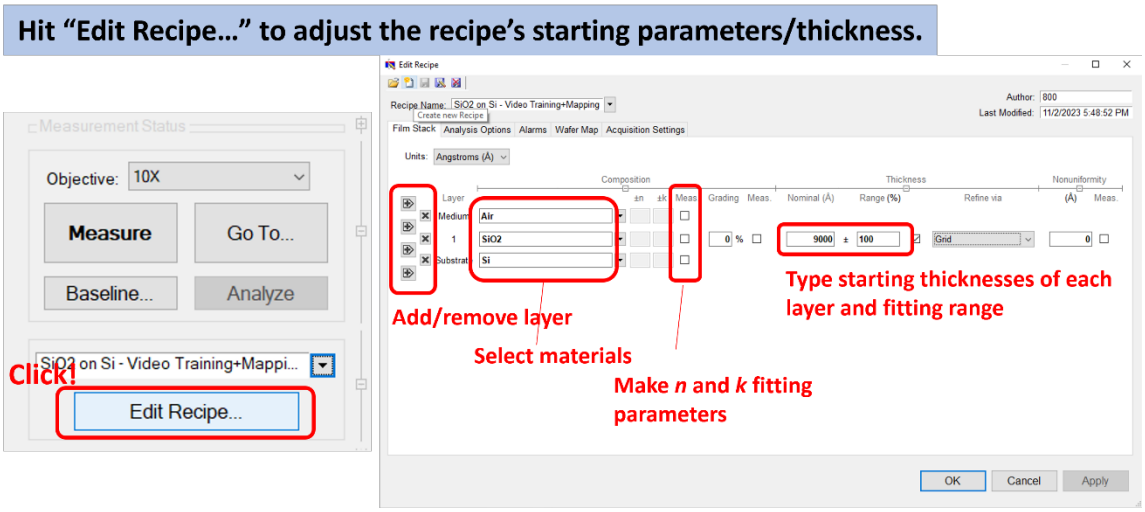
Wait for baseline measurement



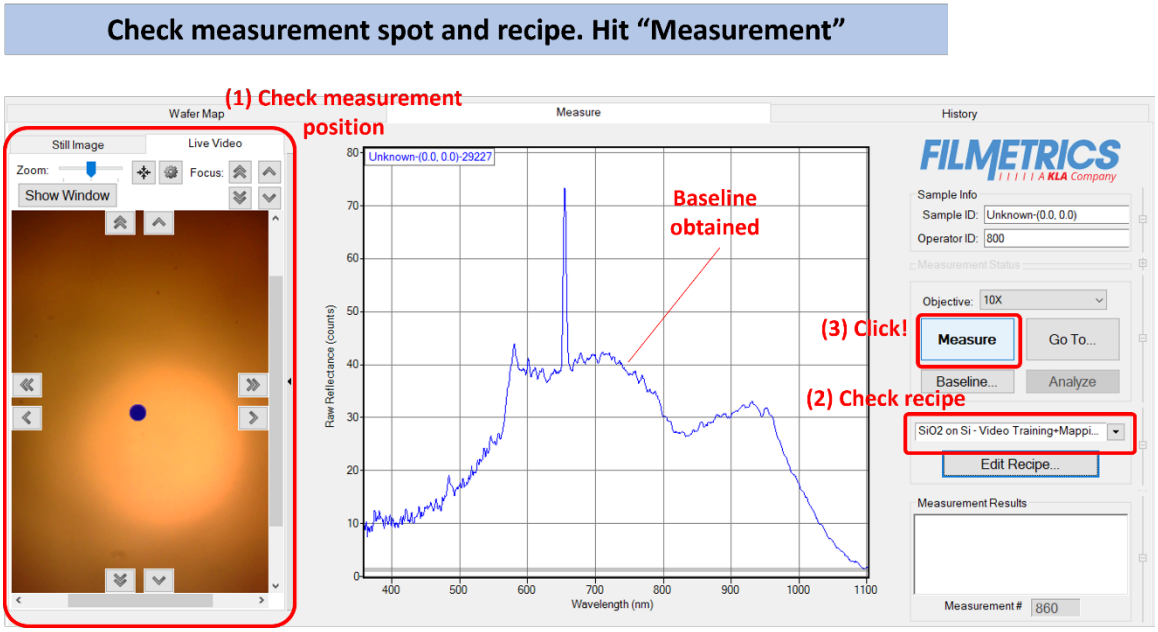
Select the recipe



4. Press **"Edit Recipe…"** to adjust the recipe's starting parameters/thickness. If you add or remove a layer or modify the material's parameters, please save the recipe with a different name. DO NOT overwrite the previous recipe. Contact a staff member for more information on recipe editing.

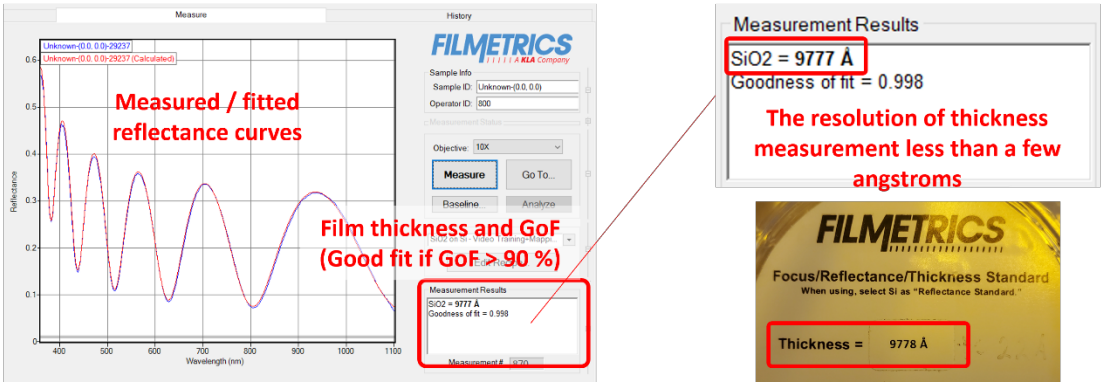


5. Once the system is baselined, your sample is in position, and your recipe is set, press the "Measure" button to scan your sample.



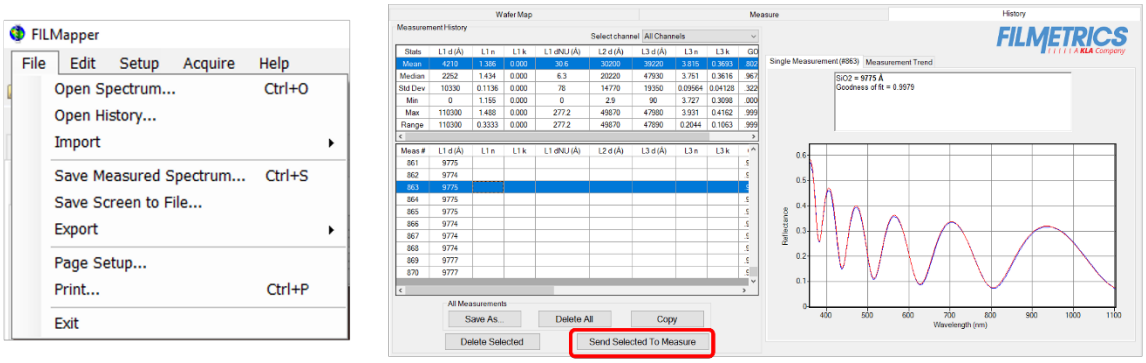
6. The film thickness and goodness of fit will appear in the bottom right of the tab in "Measurement Results."

Check reflectance results and fitting parameters



7. If a measurement needs to be saved do so using the **File** menu command "**Saved Measured Spectrum,**" "**Save Screen to File,"** and "**Saved Measured *n* and *k*"** when applicable. A variety of file formats are available for easy export. You can also access the previously measured spectra in the "History" tab.

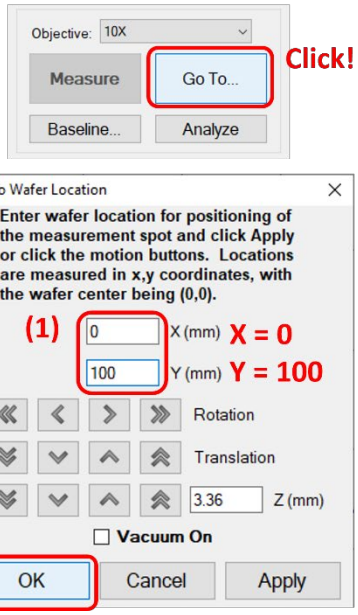
Save reflectance results in "File" menu or "History" tab



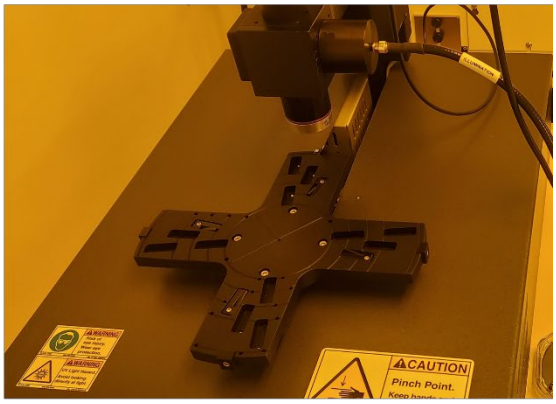
Shutting Down:

1. Bring the stage to the load/unload position at (0,100) using "**Go To…**" dialogue, remove all samples from the stage.

Navigate to sample loading position

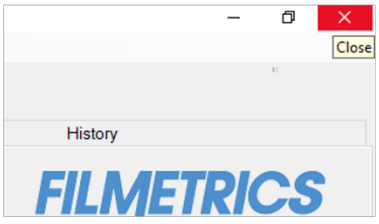


Unload sample

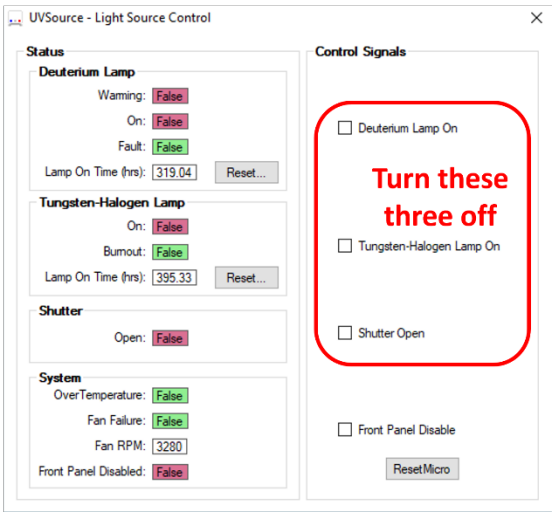


2. Press the X button in the top right of the screen. Turn off the halogen and deuterium lamps, and close the shutter, using the UVSource software. Visually confirm the lights on the light source are off.

Turn off the FLMapper software

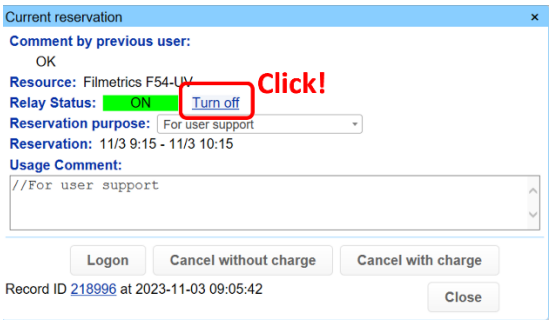


Turn off the lamps and close shutter



3. Log out of the system in FOM.

Log out of the system in FOM



7. Advanced Tips

Transparent Substrates: When measuring films on transparent substrates, reflectance from the backside of the substrate may occur. Selecting Compensate for: Unmodeled backside reflections allows the software to shift the intensity of the calculated reflectance curve to account for the additional light. This feature should not be used when measuring very thin films (< 100 nm).

Tilted Sample/Lost Light: Samples with non-coplanar surfaces scatter some of the light away from the collection optics. This option automatically compensates for the light lost due to nonplanarity.

Lock Identical Layers: Samples comprised of repeating layers can be more accurately measured by activating this option. By activating these options, all properties of any layers that initially have the same material or thickness are locked together.

Exact Spectrum Matching: The Exact Spectrum Matching is one of three analysis methods available in FILMapper. This solver can be used to measure thickness, thickness nonuniformity, and roughness of single and multilayer films, and can additionally solve for index.

Enable FFT (Thickness Only): The FFT (thickness only) solver is one of three analysis methods available in the FILMapper software. This solver is best suited for films greater than 250 nm thick, as well as multi-layered films. It is also an effective option when the index of refraction of the film isn't well known. While this feature is selected there will be fewer options under the Analysis Options tab. You cannot solve for index, roughness, or nonuniformity with the FFT (thickness only) solver enabled.

Robust Thickness: The Robust (adaptive; thickness only) solver is one of three analysis methods available within FILMapper. It is best suited for measuring the thickness of single-layer films greater than 150 nm thick. This method can oftentimes successfully measure films when the data is affected by non-ideal properties, such as thickness nonuniformity, grading, and birefringence. Much like the FFT solver, enabling Robust will limit the options

available in the Analysis options tab. You also cannot solve for roughness, nonuniformity or index with the Robust solver enabled.